Fecundity Curve of Contemporary Europe

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ABSTRACT [200 words]

Have we become more fecund compared to the past? The ability to have children is affected by environmental factors and changing lifestyles. Given the modern technological transformations, fecundity should be higher than in the past, linked to improvements in nutrition and health. On the other hand, the increase of toxins and unhealthy lifestyle should have a negative impact. We calculate the contemporary fecundity curve and compare it to historical fecundity curves. We use the German family panel pairfam, an annual longitudinal individual-level survey covering the years 2008/2009-2022, to provide an up-to-date assessment of women's and men's chances of having a child as a function of the age at which they start trying within a couple. There is a large variability in past fecundity curves, and our curve is overall in the highest range at young and mid-reproductive ages. At high reproductive ages (from around age 35 at the first attempt to have a child), the chances of ever having a child decrease as quickly as in the past.

Introduction

As women and men have children at older ages, the curve of infecundity becomes more important as it affects the ability to have children. There are arguments for both an increase and a decrease in this age-specific fecundity risk (Smarr et al., 2017). With technological and cultural advances, we have seen improvements in health, including reproductive health as well as nutrition, that seem to benefit the reproductive system and may have led to an increase in reproductive capacity at all ages over the last centuries. On the other hand, air and food pollution and other environmental factors that have come with the Industrial Revolution have all been linked to a decline in the performance of the reproductive system in both men and women (Jick et al., 1977; Mattison & Thorgeirsson, 1978; te Velde et al., 2010). Recently, assisted reproduction technology (ART) has been a breakthrough in improving the capacity to reproduce, although it has been shown that the efficiency diminishes with age (Jewett et al., 2022). Its importance has been estimated using microsimulation (Leridon, 2008), but its link to fecundity (i.e., chances of ever having a child) has not been assessed empirically. Taken together, there are many possibilities that contemporary societies will have a different fecundity curve than historical populations.

Estimates of women's chances of ever having a child by age at first attempt, based on 18th and 19th-century data from high-fertility populations in natural reproduction settings, are numerous (Barrett, 1986; Henry, 1982; Leridon, 2004; Menken et al., 1986; Vincent, 1950). Fecundity estimates range from 93-98% chance of having a child if first trying at ages 20 and 25, and then decline rapidly in the 30s to a wide range of estimates from 54-76% at age 40 and 21-50% at age 45. The most recent estimation by Leridon (2004; 2008) adjusted the historical empirical curves using simulations and obtained higher birth risk at younger ages and lower at older ages. The transition from natural to controlled reproduction, followed by the introduction of effective contraception in the mid-20th century, makes it difficult to estimate such curves today, as we need to know an individual's conception attempts instead of assuming that they are exposed to the risk of conception as soon as

they are in a partnership or having sexual intercourse. The most recent quantifications of age-specific declines in reproductive capacity only address infertility (i.e., the inability to conceive for one year), not lifelong incapacity to have a child (infecundity) (Dunson et al., 2004; van Noord-Zaadstra et al., 1991).

In this article, we provide novel estimates of fecundity by age at the first attempt to conceive in contemporary populations that allow comparison with historical estimates and extend the work to calculate male fecundity curves as well as curves that include the impact of assisted reproduction. We use the Panel Analysis of Intimate Relationships and Family Dynamics (pairfam), using waves 1-14 (2008/9-2021/2) to examine an individual's risk of being childless or not being able to conceive while trying over age and duration, defined as a couple's years of trying. The data allows us to examine individuals in partnerships who are trying to conceive specifically. This allows us to have the correct denominator when examining the risk of conception, compared to using other forms of data such as registers, where information on partnership alone is insufficient to assume that someone is trying to conceive and is therefore at risk.

Data

In the study, we use pairfam waves 1-14 (2008/9-2021/2) to examine the risk of being unable to produce a child after 4, 6, 8, and 9 years of trying. Pairfam is a multidisciplinary, longitudinal study of partnership and family dynamics in Germany, which contains 99260 person-years of experience. The population of interest is couples who are trying to conceive. We selected the population by using the question in the survey, "*Have you or your partner tried to have a child since the last interview*?" we also included events where the couple never indicated trying to have children but became pregnant. Moreover, we restrict the data so that the individual has been observed at least twice and is not in a same-sex male relationship, as we would not know the age of the female child-bearer. The study population is reduced to 2854 individuals with 3634 person-years of observations.

By using couples who say they are trying to have a child as the exposure population, we impose a stricter definition of the population of exposure, overcoming the limitations of using population data such as register data. Having accurate exposure in both the numerator and denominator allows us to create empirical curves of estimates over time.

Method

In this article, we will use a penalized spline Cox proportional hazards model. The model can be expressed as:

$$h(t \mid age, sex) = h_0(t) * \exp\left(f(age) + \beta_2 sex\right) (1)$$

In the model, we estimate the risk of a birth event by incorporating the time at risk (i.e., the length of time the couple has been trying, t, into the baseline hazard. We introduce smoothed age splines, f(age), to allow flexibility in understanding how age influences the relative risk of birth over time. In addition, we include the sex of the individuals. Penalized splines (p-splines) are used because

they offer a flexible way to estimate smoothed rates over a continuous variable by penalizing the function to avoid overfitting and maintain smoothness.

We then calculate the predicted fecundity conditioned on age and sex. We estimate confidence intervals by predicting the function and applying a 1.96 multiplier to the standard error on each side.

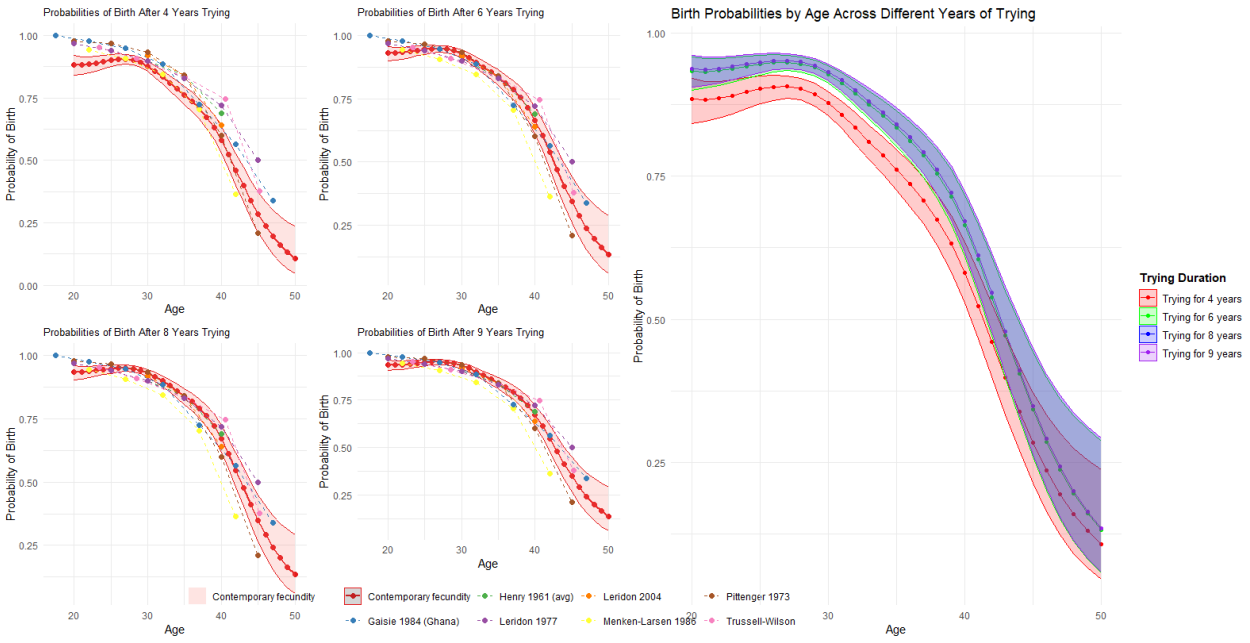
We compare these model estimates with previous models to assess changes in the risk of giving birth, particularly as a function of time spent trying to conceive in a couple. While previous research has often focused on a 4-year time frame for trying (Leridon, 2004), we expand this definition to include 4, 6, 8, and 9 years of trying. Most couples in our dataset tried for 2 to 4 years before leaving the panel (due to attrition, separation, or birth), with a maximum observed duration of 11 years. We examine the risk of a birth event by creating fecundity curves conditioned by years of trying and extrapolate these risks to longer durations. In our sample, 31% of individuals were observed for 2 years, 8% for 4 years, and 2% for 7 years or more.

Preliminary results

We are presenting the results of the exploratory model. We will have the final results for women and men and by mode of conception for IPC 2025.

The figures show the curves of the probability of birth that we estimated with our models at four chosen durations (4,6,8,9). On the left-hand-side panel, they are compared with the estimates based on historical data. On the right-hand-side panel, we compare our estimates for different durations. Most of the persons who will succeed in having a child do so within 4 years of the first attempt. After that duration, the improvement by trying longer is visible until 6 years, but after that duration, it becomes marginal.

Overall, the chances of having a child are the highest in the late 20s and start declining from then on, increasingly quickly, until they reach 0 for those who start trying to have a child after age 40. The curve is not exponential like the one of Leridon: we observe notably a slight bump in the late 30s, which may, however, be explained by the use of assisted reproduction. Further estimates that exclude births through assisted reproduction will complement these first curves for the conference.



Preliminary conclusion

In contrast to previous models, we have estimated the slope of the fecundity curve from age 20 to 50. Compared to previous models, we find that the fecundity pattern seems higher than other estimates in the late 20s-early 30s, which may be explained by a combination of better health and ART use (although it is mainly used from age 30). Our results thus indicate that the increase in life expectancy and technological advancement in assisted reproductive technologies significantly increase fecundity between ages 28 and 39. On the other hand, after that age, the capacity to conceive a child decreases quickly, and our estimates are generally lower than past estimates. We plan to explore these age patterns more in detail, integrating partnership status, parity, and use of ART.

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